

Development of Environmental Qualification and Acceptance test Requirements for the Constellation Program and Comparison with MIL-STD-1540E

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24th Aerospace Testing Symposium

April 6, 2008

CONSTELLATION





Outline



- ◆ **Constellation Program Description**
- ◆ **Test & Verification challenges within Constellation Program**
- ◆ **Development of the CEQATR**
- ◆ **Comparison between CEQATR and MIL-STD 1540**

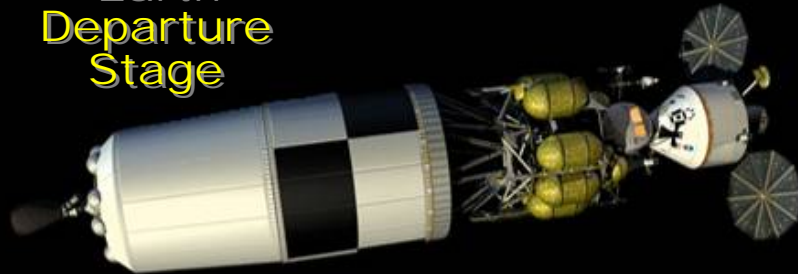




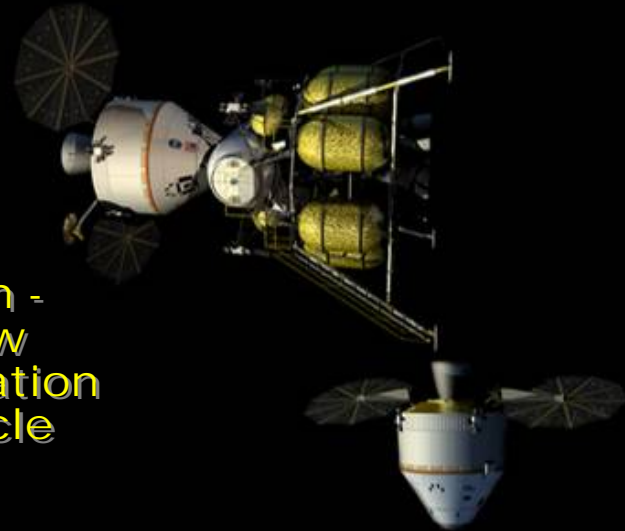
Constellation Program Spacecraft



Earth
Departure
Stage



Orion -
Crew
Exploration
Vehicle



Ares V -
Heavy
Lift
Launch
Vehicle



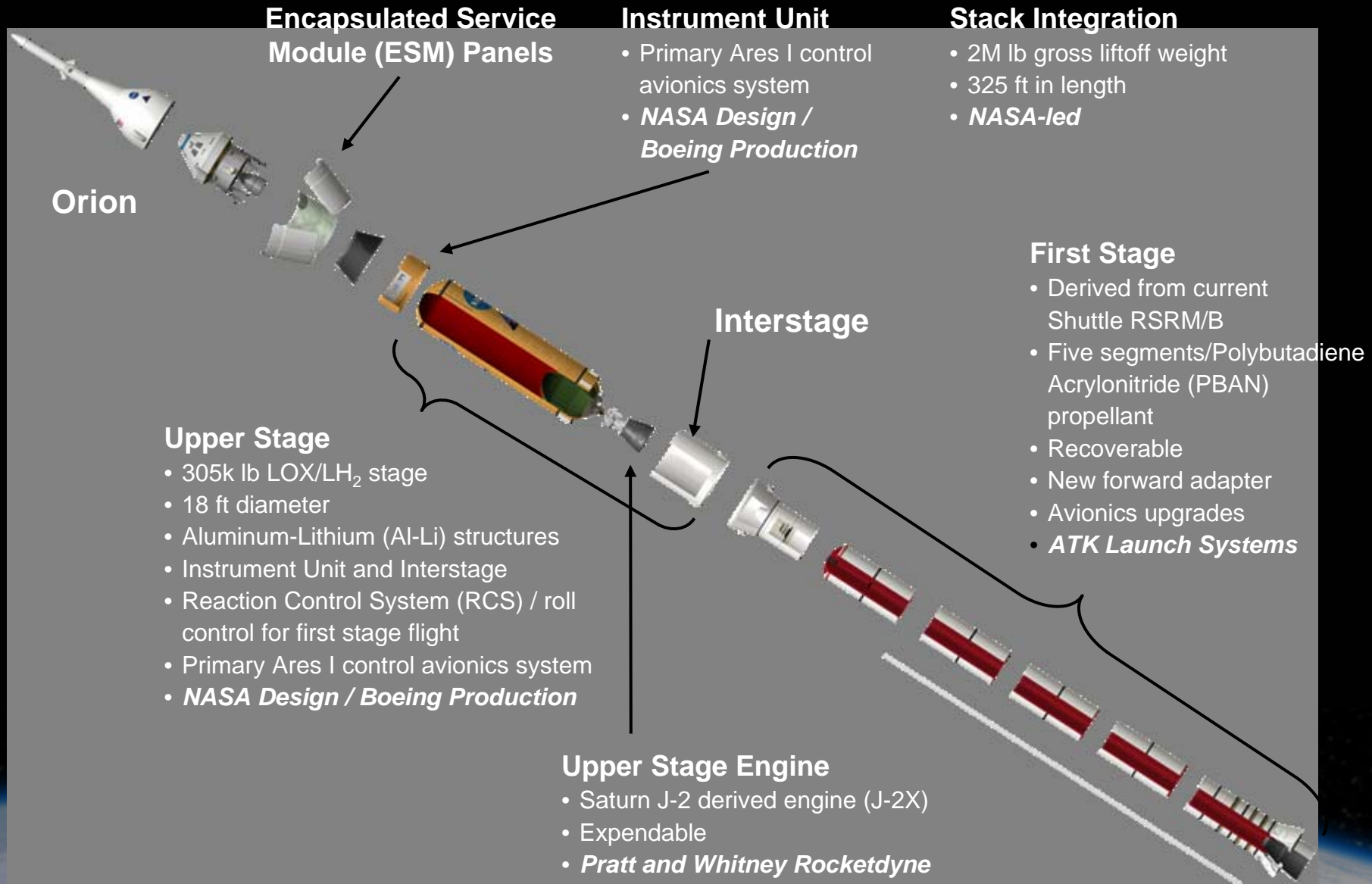
Ares I -
Crew
Launch
Vehicle



Altair-
Lunar
Lander



Ares I Elements



Orion Crew Exploration Vehicle (JSC)

Crew Module (JSC)

- Crew and cargo transport
- Under Prime contract

Spacecraft Adapter (GRC)

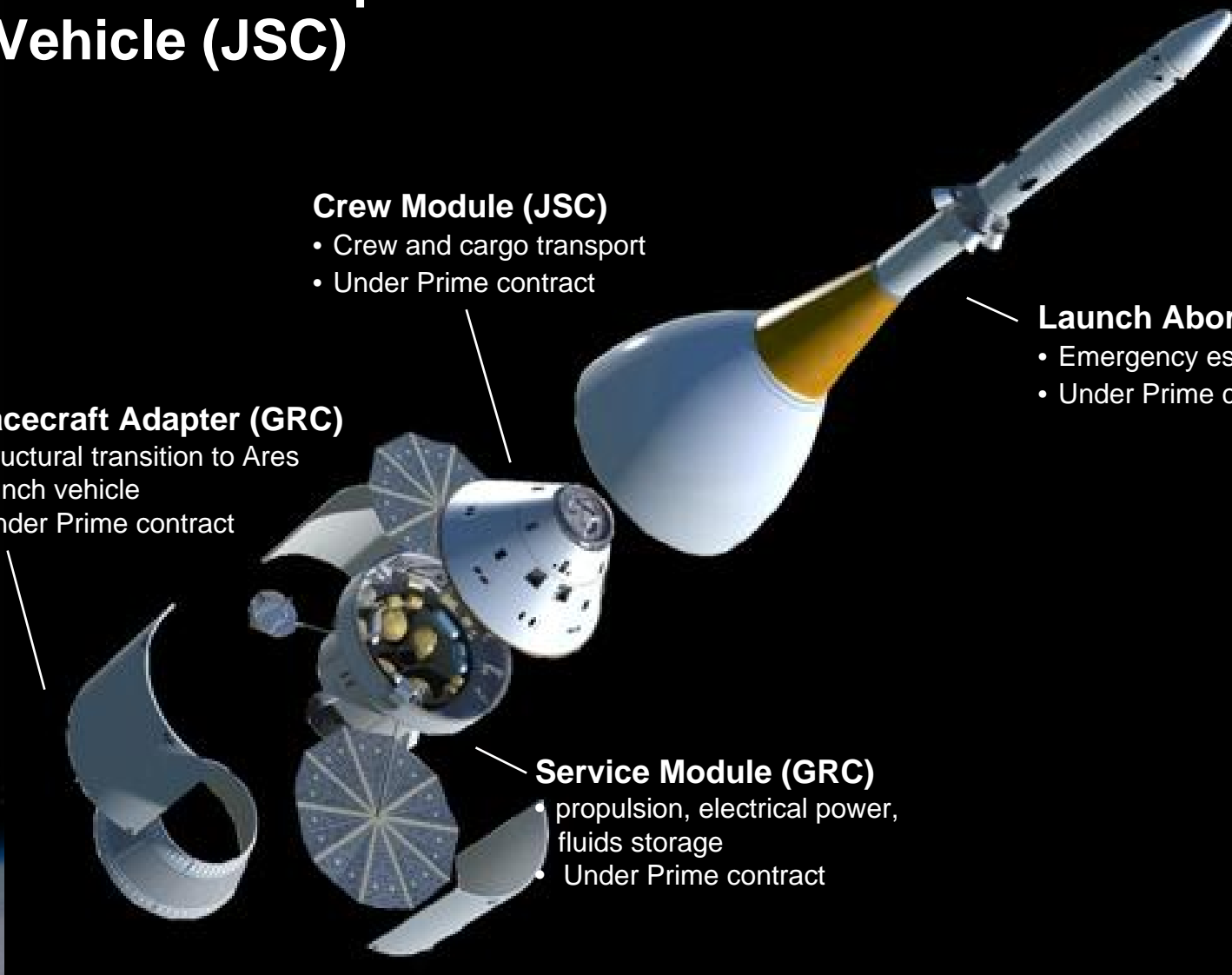
- Structural transition to Ares launch vehicle
- Under Prime contract

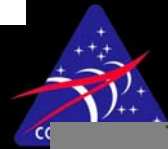
Launch Abort System (LaRC)

- Emergency escape during launch
- Under Prime contract

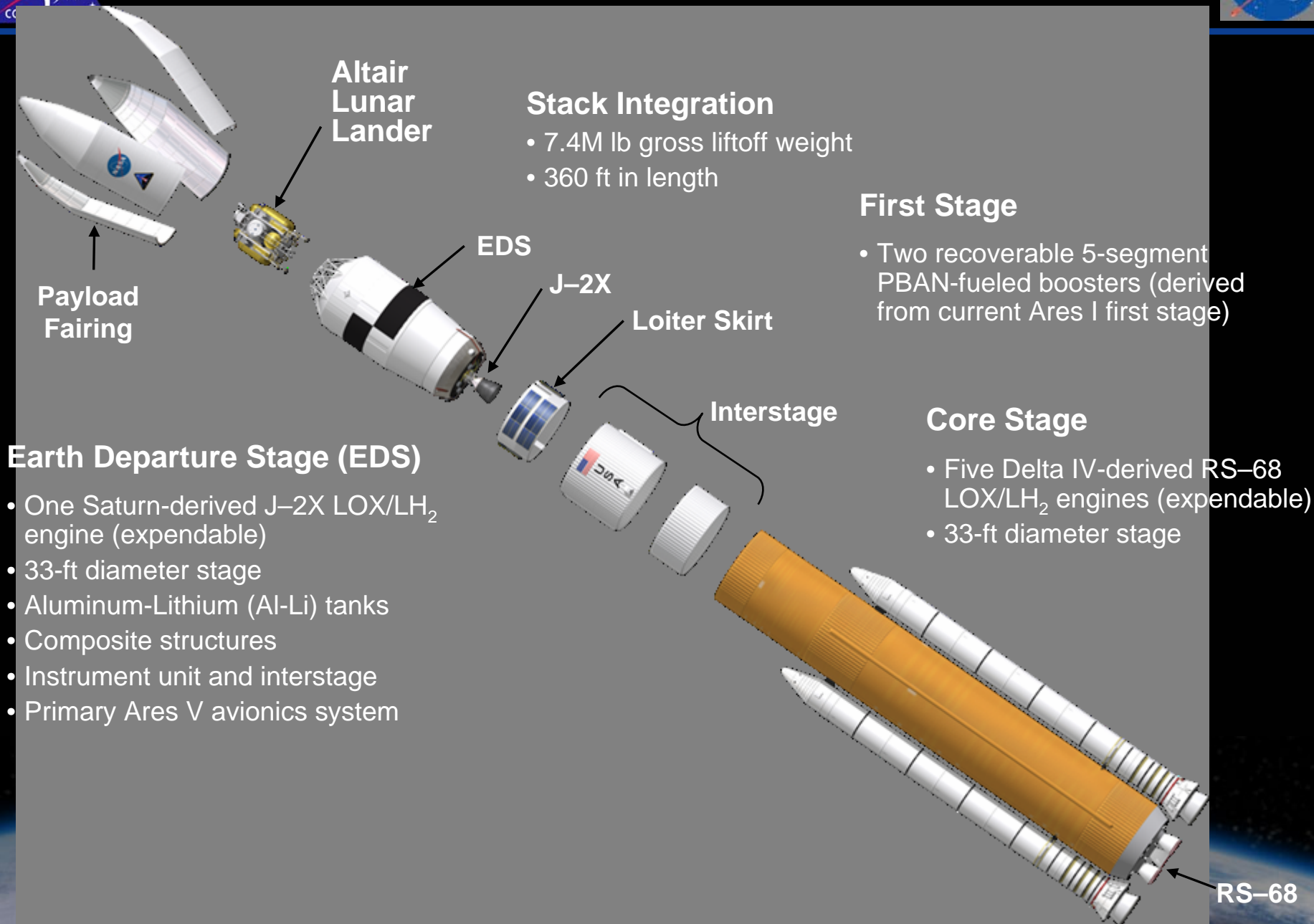
Service Module (GRC)

- propulsion, electrical power, fluids storage
- Under Prime contract





Ares V Elements



NASA's Past, Present, and Future Launch Vehicles

(Shown to scale)



Apollo Saturn V
363 ft



Space Shuttle
184 ft



Ares I
328 ft



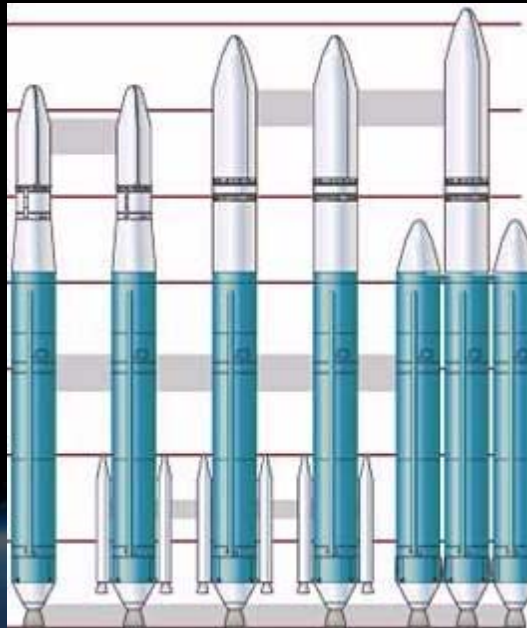
Ares V
361 ft

Launch Vehicle Size Comparison

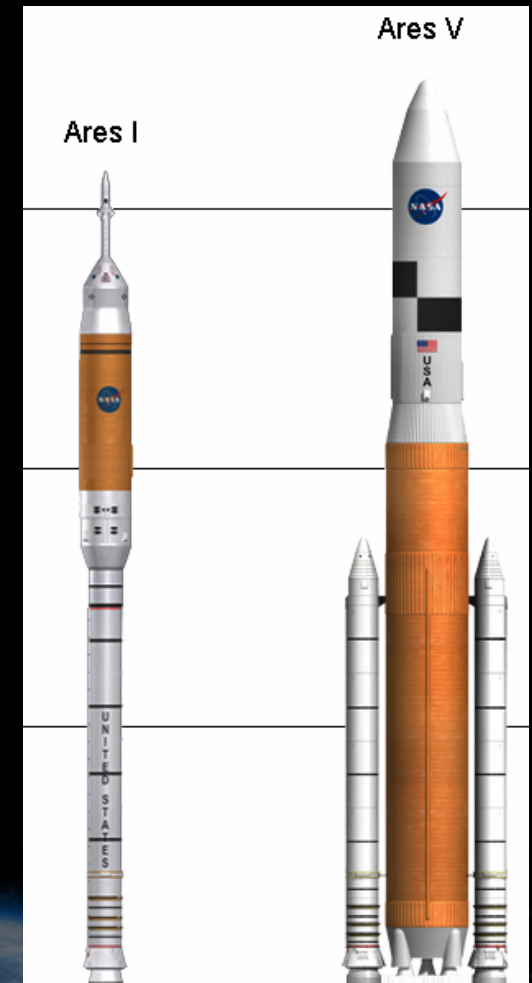
Atlas



Delta



Ares



Source: Google Images
Relative size is approximate only

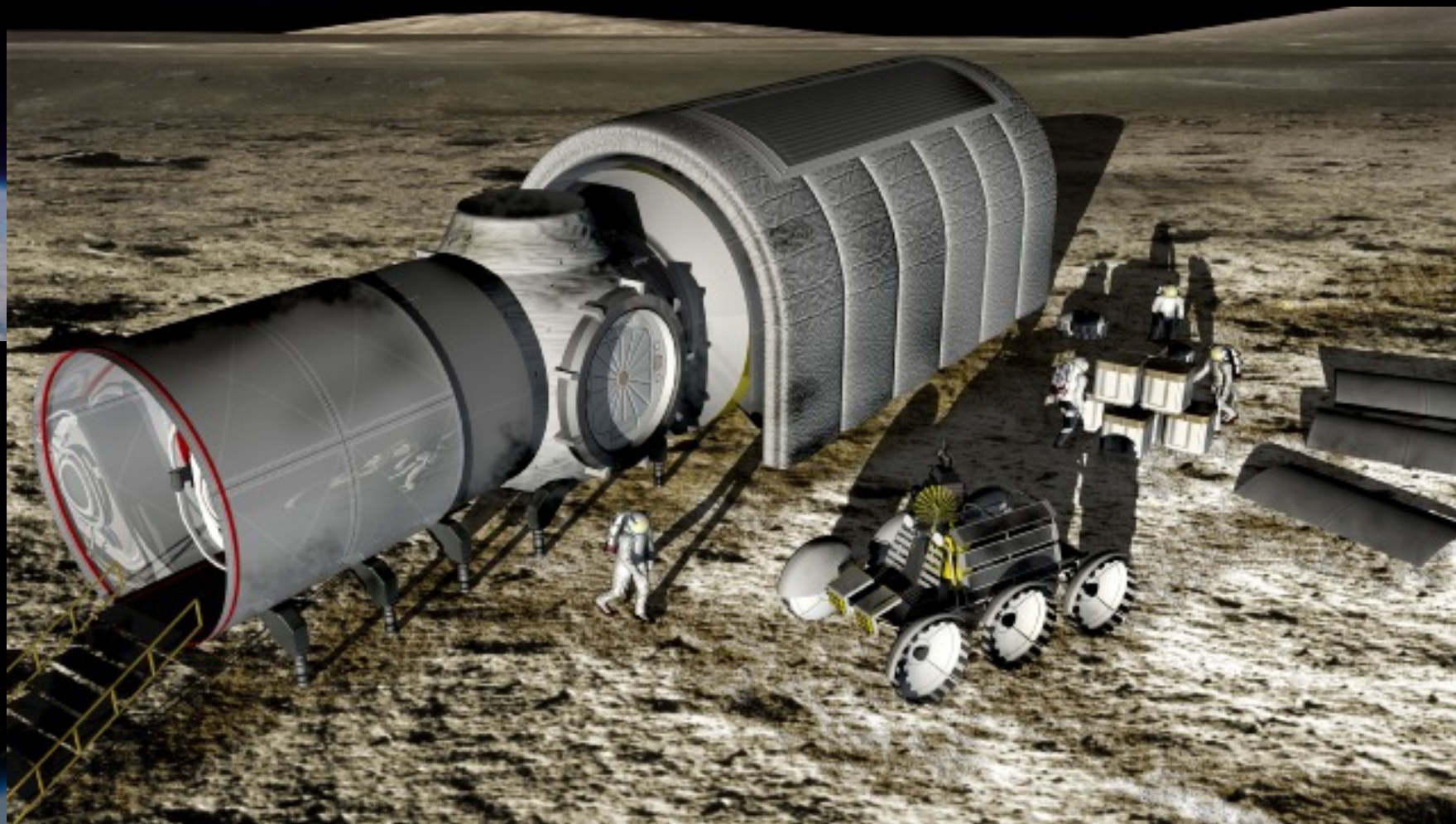


Diversity in Unmanned Systems



Source: Google Images

Diversity in Human Rated Systems



Map of Constellation content across NASA



Ames

- ◆ Lead Thermal Protection System ADP
- ◆ Aero-Aerothermal database
- ◆ Ares Abort simulations
- ◆ Software and GN&C support



Glenn

- ◆ Lead Service Module and Spacecraft Adapter integration
- ◆ Flight Test Article "Pathfinder" fabrication
- ◆ Ares I-1 upper stage simulator lead
- ◆ Ares power, TVC and sensors lead
- ◆ J-2X altitude/inspace testing
- ◆ SE&I Support



Goddard

- ◆ Communications Support



Langley

- ◆ Lead Launch System integr
- ◆ Lead landing system ADP
- ◆ Ares I-1 vehicle integration
- ◆ Ares aerodynamic lead
- ◆ SE&I Support



Kennedy

- ◆ Home for Ground Ops Project
- ◆ Ground processing
- ◆ Launch operations



Marshall

- ◆ Home for Ares Project
- ◆ Ares I and V development and integration lead
- ◆ LAS and SM SE&I Support



Stennis

- ◆ Rocket Propulsion Testing for Ares

Johnson

- ◆ Home for Program
- ◆ Home for Projects: Orion, Mission Ops, EVA, Lunar Lander
- ◆ Lead Crew Module integration
- ◆ Orion Spacecraft Integration
- ◆ GFE projects management
- ◆ Flight Test Program



Dryden

- ◆ Lead Abort Flight Test Integration/Operations
- ◆ Abort Test Booster procurement
- ◆ Flight Test Article Development/Integration

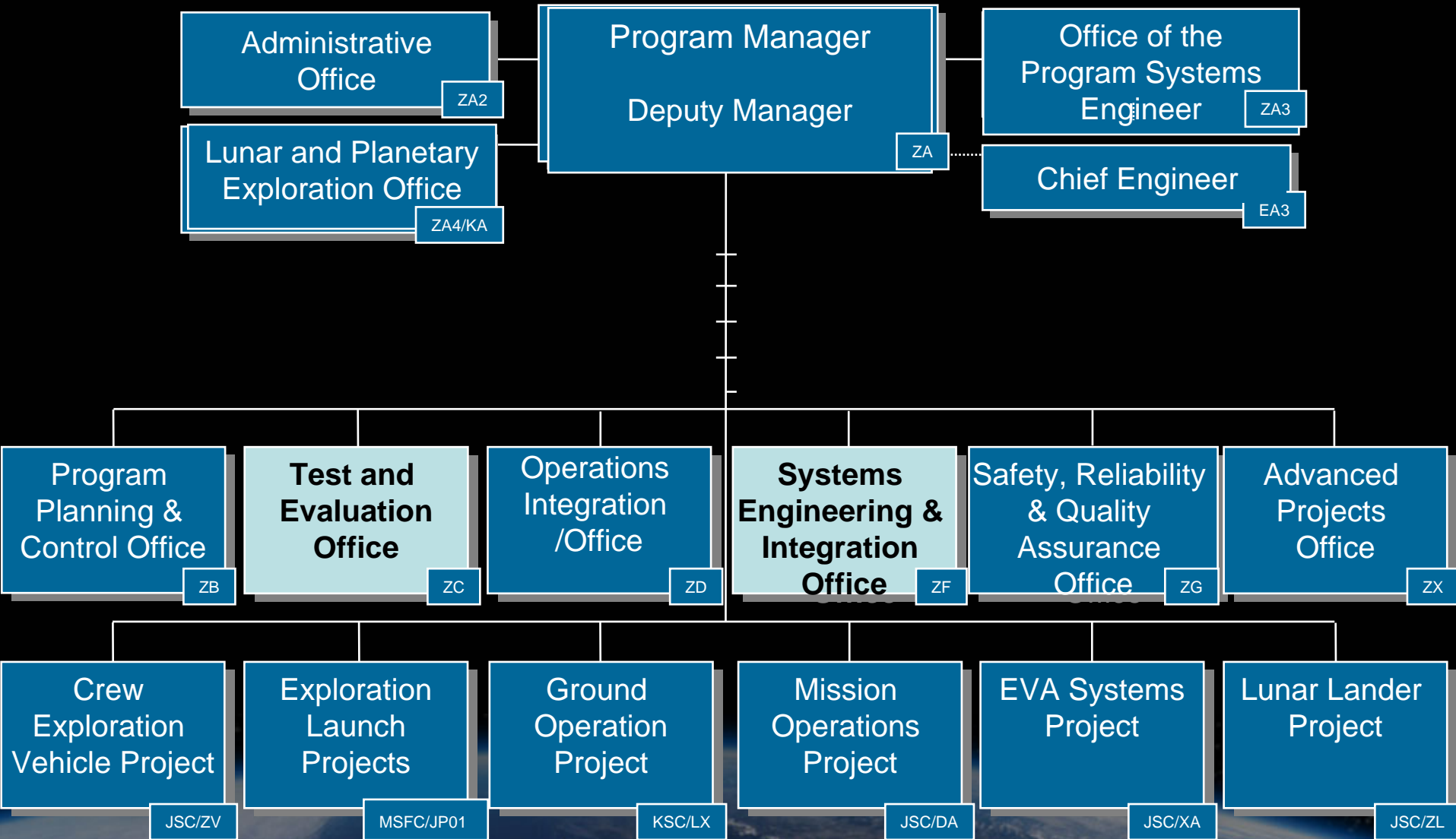
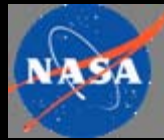


JPL

- ◆ Thermal Protection System support



Constellation Program





Challenges



- ◆ Integrating multiple NASA centers, project offices, and contractors
- ◆ Aging of workforce and loss of expertise from previous programs
- ◆ Extended development cycles between major programs
- ◆ Practices from previous programs not always applicable for Constellation





Vision for CxP Environmental Testing



- ◆ Establish excellence agency-wide in verification discipline
- ◆ Capture latest industry/government/NASA best practices (learn from everyone)
- ◆ Recognize increased inherent risk of CxP lunar missions over LEO Shuttle/ISS (and even Apollo) missions
- ◆ Establish common terminology/understanding
- ◆ Provide training to establish minimum level of testing competence, convey CEQATR-specific expectations
- ◆ Establish consistent, program-wide, minimum standards, but allow **risk-based** tailoring
- ◆ **Selectively** incorporate lessons learned from previous and present programs in order to allow for more effective testing for CxP and future programs.
- ◆ Define testing early to avoid surprises at delivery
- ◆ Build and sustain the as-certified baseline and hardware test record.



Instead of CEQATR, why not use...



MIL-STD-1540E Test Requirements for Launch, Upper-
Stage and Space Vehicles

MSFC REQT-3019 Launch Vehicle Qualification
Requirements

SP-T-0023 Space Shuttle Specification Environmental
Acceptance Testing

SSP 41172 Space Station Program Qualification and
Acceptance Environmental Test Requirements

NASA STD 7001 Payload Vibroacoustic Test Criteria

NASA STD 7002 Payload Test Requirements

NASA STD 7003 Pyroshock Test Criteria



Technical Drivers for Differences Between Documents



- ◆ Differing Mission Profiles
- ◆ Differing Configurations
- ◆ Fitting within existing NASA documentation



Example Comparison Chart

	Electrical and Electronic	Antenna	Mechanism (Moving Mechanical Assy)	Solar Array	Battery	Valve or Propulsion	Pressure Vessel or Component	Fluid Equipment	Pressure Vessel (9)	Thruster	Thermal	Optical	Structural
Specification Performance (1)	R	R	R	R	R	R	R	R	R	R	R	R	R
Leakage (2,9)	ER R	-	R ER	-	R	R	R	R	R	R	R	- R	-
Shock (10)	R	ER	ER	ER	R(6) ER	ER	ER	ER	ER	ER	ER	ER	ER
Vibration or Acoustic (2)	R	R	R	R	R	R	R			R	R	R	ER
Random Vibration	R	R(3)	R	R(3)	R			R	R		R	R	
Acoustic Vibration	-	R(3)	-	R(3)	-			-	-		-	-	
Sinusoidal Vibration	ER	ER	ER	ER	ER			ER	ER		ER	ER	
Acceleration	ER	ER -	ER -	ER -	ER	-	ER	ER	-	-	- ER	ER	ER
Thermal Cycle	R	ER	ER	ER	R ER	ER	ER	R	ER	ER	ER	ER	ER(3)
Thermal Vacuum (7)	R R(13)	R	R R(6)	R	R	R	R	R	R	R	R	R R(13)	-
Thermal Gradient	-	-	ER	ER	-			-	-		ER	ER	
Climatic	ER	ER	ER	ER	ER	ER	ER	ER	ER	ER	ER	ER	ER
Pressure	ER	-	ER	-	R	R	R			ER	ER(5)	-	-
EMC (4)	R	R	ER	ER	ER	ER	ER			ER	ER	ER	ER
Plasma/Arcing	-	-	-	R	-			-	-		-	-	
Life (8)	ER -	ER -	R	ER -	R	R	ER	ER	R(11)	R	ER	ER -	ER
Burst Pressure	-	-	ER	-	R	R	R			R	ER	-	-
Static Load	ER	ER	ER	ER	R	-	ER			-	-	-	R
Depressurization/Repressurization	R	-	R	-	R			R(7)	ER		R(7)	ER	

Red indicates unique CEQATR content

Blue indicates unique 1540 content



Differences in Scope



MIL-STD-1540

Inspection

Specification Performance

Leakage

Shock

Vibration or Acoustic

Acceleration

Thermal Cycle

Thermal Vacuum

NA

CxP CEQATR

NA

Functional/Performance

Leak

Shock

Random Vibration

Acoustic Vibration

Sinusoidal Vibration

Acceleration

Thermal Cycle

Thermal Vacuum

Thermal Gradient



Differences in Scope (cont.)



MIL-STD-1540

NA

Climatic

NA

EMC

Life

Pressure

Static Load

CxP CEQATR

Plasma/Arcing

Climatic

Depressurization/
Repressurization

NA – Covered elsewhere

Life

NA – Covered elsewhere

NA – Covered elsewhere





Test requirements in other CxP documents



Test

Acoustic Noise

EMC

Ionizing Radiation

Modal Survey, Pressure,
Static Load

Offgas, Outgas, Oxygen
Compatibility

Run-In

Ozone

Atomic Oxygen

Propulsion Hot Firing

Governing CxP Document

Human-Systems Integration Requirements

Electromagnetic Environmental Effects (E3)
Requirements

Electromagnetic Environmental Effects (E3)
Control Plan

Ionizing Radiation Control Plan

Structural Design and Verification Requirements

Standard Materials and Processes Requirements
for Spacecraft

Design and Development Requirements for
Mechanisms

TBD

TBD

TBD



Unit Nomenclature



MIL-STD 1540

Electrical and Electronic

Antenna

Moving Mechanical Assembly
(MMA)

Solar Array

Battery

Valve or Propulsion Component

Pressure Vessel or Component

Thruster

Thermal

Optical

Structural Components

CxP 70036

Electrical or Electronic Equipment

Antenna

Mechanism

Solar Panel

Battery

Fluid Equipment

Pressure Vessel

NA – covered elsewhere

Thermal Equipment

Optical Equipment

NA – covered elsewhere



Environmental Test Requirement Definition Process



- ◆ Comparison of test approaches among participants
- ◆ Discussion of “best” requirements
- ◆ Comparison of historical test data and effectiveness of different approaches and parameters
- ◆ Discussion of **technical** factors driving different approaches/requirements
 - Eliminate “emotioneering”
- ◆ Increased understanding among participants
- ◆ Follow-on negotiation of test requirements
- ◆ **Establishment of Test & Verification Community of Practice**



Environmental T&V CoP



NASA Engineering Network

Viewing Communities > Engineering

NASA Engineering Network | NASA Details | Account | My Profile | My Recent | Search

Search for:

Search

Viewing Communities > Engineering

Engineering Communities > Environmental Test and Verification

Environmental Test and Verification

Main Page | Documents, Documents and Resources | Project Notes and Tasks

Announcements for Environment of E&V

24th Annual National Test & Evaluation Conference Palm Springs, CA, February 25-29, 2000

Dec 27, 2007

Test and Evaluation Autonomous Systems: The Role of the T&E Community in the Requirements Process?

Military Testing & Evaluation, Georgetown Univ. Conf. Ctr (and Hotel), Washington, DC, Jan. 29-30, 2000

Dec 27, 2007

Testing and Evaluation (T&E) is a critical component of top defense acquisition programs.

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Upcoming Conferences - Environment T & V

edit

Military Testing & Evaluation

January 29-30, 2000 - Georgetown University Conference Center (and Hotel), Washington, DC

ADAA U.S. Air Force T&E Days

February 5-7, 2000 - Sheraton Gateway Hotel Los Angeles Airport - Los Angeles, California

24th Annual National Test & Evaluation Conference Palm Springs, CA

February 25-29, 2000 Test and Evaluation of Autonomous Systems & The Role of the T&E Community in the Requirements Process

24th Aerospace Testing Seminar

April 10-12, 2000 - Manhattan Beach Marriott, Manhattan Beach, CA
Prereq Seminar April 7, 2000

ICETC 2000, ICET 54th Annual Technical Meeting

May 4-7, 2000 - Hilton Bloomington Indian Lakes Resort - Bloomington, Illinois

25th Space Simulation Conference

October 20-23, 2000 - Doubletree Hotel, Annapolis, Maryland

Peak Events:

ITCA Space & Missile T&E Symposium

11-12 September 2007, Colorado Springs, Colorado, four tracks to T&E Director

Welcome to Environmental T&V



This is the place to exchange information on the Environmental Test and Evaluation and Test and Evaluation.

For more information, click on the links on the right side of the page.

Administrative: Knowledgebase & Discussion

Click here to view the help page.

Environmental T & V Quick Links

There are no saved items

Useful External Links

- Aerospace Testing Seminar
- International Test and Evaluation Symposium
- Test and Evaluation Autonomous Systems & The Role of the T&E Community in the Requirements Process
- 2000 Engineering Test and Evaluation Conference
- Space Simulation Conference
- Test and Evaluation Symposium
- Test and Evaluation Symposium

Calendar - Environmental T & V

Calendar

2007-2008

S	M	T	W	T	F	S
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				



Big Issues



- ◆ Unit acceptance vibration duration
- ◆ Shock testing for acceptance
- ◆ Margins/Maximum Predicted Environment
- ◆ Major Assembly Testing
 - Upper Stage
 - Space Vehicle
- ◆ Thermal Cycle Limits
- ◆ **Qualification Random Vibration Approach**
 - Two-phase CEQATR approach (QAVT/QVT) vs single enveloping test (baseline 1540 approach)
- ◆ Order of EMI in Test Sequence
 - First or last?
- ◆ Understanding of Tailoring



Back to Basics



- ◆ **Why am I testing again?**
- ◆ **Is the test effective in driving out latent defects?**
 - **Are the proposed test levels sufficient to excite the hardware?**
 - **Does my configuration have components that will be excited by the test?**





Current Status



- ◆ **Revision A Baselined**
- ◆ **Revision B in Work**
 - **Environmental tests, including humidity**
 - **Clarification**
 - **Low Frequency Vibration**
 - **Biased Tolerances for Vibration/Acoustic**
 - **Thermal Uncertainty/MPE**





Questions?

